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ABSTRACT

This agriculture extension service publication from Pennsylvania State University examines weed control and identification in vegetable crops. Contents include: (1) Types of weeds; (2) Reducing losses caused by weeds, general control methods and home garden weed control; (3) How herbicides are used; (4) Specific weeds in vegetable plantings; and (5) Terms used in selective weed control. Additionally, this publication is written for the home gardener and does not discuss specific herbicides. (MR)

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College of Agriculture, The Pennsylvania State University, University Park, Pennsylvania

WEED IDENTIFICATION AND CONTROL

IN VEGETABLE CROPS

Weeds are costly. They compete with vegetable crops for water, fertilizer, and light, and they often reduce yield and quality. They increase labor and equipment costs, harbor insect and disease organisms, and reduce land values. Weeds cost the American farmer an estimated 7.5 billion dollars annually. In certain crops, the yearly losses due to weeds can exceed $150 per acre. In many crops, such losses can mean the difference between success and failure.

For our purposes, a weed is defined as any unwanted plant. Most weeds are wild plants; however, crop plants growing out of place are also weeds. Volunteer small grain or sweet corn growing in a direct-seeded tomato field can be considered serious weeds.

Almost all plants have now been categorized into a plant classification system and given a scientific name to identify them anywhere in the world. From this classification, weeds can be identified and proper control methods can be selected.

TYPES OF WEEDS

Weeds in vegetable crops fit into three fairly distinct categories--grasses, sedges, or broadleaves. All true grasses are members of the Gramineae family. The only sedge of importance is nutsedge (often called "nutgrass"). All other weeds are considered to be broadleaf types.

Weeds may also be classified as summer annuals, winter annuals, biennials, or perennials. Each group of weeds follows a distinct life cycle on which the control program is usually based.

Summer annual weeds grow every spring or summer from seed; they produce seed, mature, and die in one growing season.

Seed from most summer annual weeds germinate mainly during a two-month period in May and June. Then the seed lies dormant until the next spring. A few seeds of every species germinate during summer or fall, but seldom in numbers equal to the spring flush. Of the millions of weed seed lying beneath every square foot of land, probably not more than 5 percent will germinate in any growing season. Where annual crops are sown in the spring, summer annual weeds are the greatest problem because their seed germinates most readily in disturbed soil.

Winter annual weeds come up in late summer or fall from seed, then mature and produce seed the following summer. Seed of most winter annuals are dormant in the spring but germinate in the late summer or fall. Some species, such as common chickweed, can germinate under snow cover. These weeds start growing at the first sign of spring, and many species bloom and produce ripe seed by mid-May or June. This means that some weeds can reseed themselves before land is prepared for late-planted crops, such as cucumbers, squash, beans, and transplants of melons, tomatoes, peppers, and eggplant.

Biennial weeds grow from seed anytime during a growing season. They normally produce a rosette of leaves close to the soil surface the first year; then they flower, mature, and die the following growing season.

Wild carrot and bull thistle are two of the most common biennial weeds in Pennsylvania. A true biennial never produces flowers or seeds in its first year.

Perennial weeds become established by seed or by vegetative parts, such as root stocks or rhizomes, and they live for more than two years. Since perennial weeds live indefinitely, their persistence and spread is not as dependent on seed as are the other three weed groups. Seed is the primary method of introducing these weeds into new areas; however, perennial weeds are often spread during soil preparation and cultivation. Most perennial weeds that spread by rhizomes or root stocks will spread in circular patches, if left undisturbed. In cropped fields, patches of quackgrass, Canada thistle, and johnsongrass spread in oblong patches in the direction the field is worked.

Seedling perennials are no more difficult to control than any other weed seedlings. However, once established, perennial weeds are the most difficult to control and the most competitive with annual vegetable crops.

Some of the most important common weeds of vegetable crops are:

SUMMER ANNUALS

Grasses

- Barnyardgrass, Echionochloa crusgalli
- Fall panicum (spreading panicgrass), Panicum dichotomiflorum
- Foxtails
  - Giant foxtail, Setaria faberii
  - Green foxtail (green bristlegrass), Setaria viridis
  - Yellow foxtail (yellow bristlegrass, pigeon grass), Setaria lutescens
- Goosegrass (yardgrass, silver crabgrass), Eleusine indica
- Large crabgrass (large hairy crabgrass), Digitaria sanguinalis
- Sandbur (burgrass), Cenchrus pauciflorus
- Stinkgrass (lovegrass), Eragrostis cilianensis
- Witchgrass (tumble panicgrass), Panicum capillare

Broadleaf weeds

- Annual morningglory, Ipomoea purpurea
- Black mustard, Brassica nigra
- Black nightshade, Solanum nigrum
- Carpetweed, Mollugo verticillata
- Cocklebur (clotbur), Xanthium pennsylvanicum
- Common ragweed, Ambrosia artemisiifolia
- Field dodder (actually a parasitic plant lacking chlorophyll), Cuscuta pentagona
- Galinsoga
  - Hairy galinsoga, Galinsoga ciliata
  - Small flower galinsoga, Galinsoga parviflora
- Henbit, Lamium amplexicaule
- Jimsonweed, Datura stramonium
- Lambsquarter, Chenopodium album
- Pennsylvania smartweed, Polygonum pennsylvanicum

Pigweed
    Prostrate pigweed (mat amaranth), Amaranthus graecizans
    Rough pigweed (redroot), Amaranthus retroflexus
Purslane (pusley), Protulaca oleracea
Velvetleaf (Indian mallow, butter print), Abutilen theophrasti
Venice mallow (flower-of-the-hour), Hibiscus trionum
Wild Buckwheat (black bindweed), Polygonum convolvulus

WINTER ANNUALS (all broadleaf types)

Common chickweed, Stellaria media
Dog fennel (mayweed), Anthemis cotula
Indian mustard, Brassica juncea
Shepherdspurse, Capsella bursa pastoria
Wild mustard (charlock), Brassica kaber

BIENNIALS (all broadleaf types)

Bull thistle (spear thistle), Cirsium vulgare
Field pepperweed (field peppergrass, cow cress), Lepidium campestre
Wild carrot (Queen Anne's lace), Daucus carota
Yellow rocket (winter cress) (sometimes a winter annual or perennial), Barbarea vulgaris

PERENNIALS

Grasses
    Bermuda grass (devilgrass), Cynodon dactylon
    Johnsongrass, Sorghum halepense
    Quackgrass (couchgrass), Agropyron repens
Broadleaf weeds
    Broadleaved dock, Rumex obtusifolius
    Buckhorn plantain (ribgrass), Plantago lanceolata
    Canada thistle (creeping thistle), Cirsium arvense
    Dandelion, Taraxacum officinale
    Field bindweed (creeping jenny, small morningglory), Convolvulus arvensis
    Groundcherry, Physalis spp.
    Horsenettle (sand brier), Solanum carolinense
    Mouse-ear chickweed, Cerastium vulgatum
Sedges
    Yellow nutsedge, Cyperus esculentus

REDUCING LOSSES CAUSED BY WEEDS

Weed losses can be reduced by prevention, eradication, or control.

Weed prevention primarily means good farm sanitation. You start with weed-free fields, and then you prevent weeds from being introduced, from spreading, or from going to seed. Preventive methods include using clean seed, cleaning contaminated equipment, keeping fence-row and ditch-bank weeds from seeding and spreading, and spot treating small weed infestations within the field.

Weed eradication completely destroys or removes all weed plants, including regenerating plant parts. Eradication is sometimes justifiable, as in the case of small new infestations of particularly troublesome weeds (such as dodder), even at relatively high costs or even when a portion of the crop must be sacrificed.

Weed control is usually the most reasonable approach. Many weeds are so widespread that eradication--though desirable--becomes economically impractical. You can, however, use control measures to reduce the infestation to a level that will enable you to produce a profitable crop in spite of the weeds.

GENERAL CONTROL METHODS

Weeds can be controlled by one or a combination of four methods: mechanical, rotational cropping, biological, or chemical. A long-range program combining all four methods into a total system provides maximum results.

Mechanical weed control includes cultivating, mulching, mowing, burning, and hoeing. Pulling escaped weeds by hand is occasionally necessary.

Black plastic mulch used at planting for all warm-season crops such as tomatoes, peppers, and vine crops will:

a. Help control weeds
b. Increase soil temperature 8 to 10° F. above areas that have not been black-plastic mulched early in the season
c. Eliminate soil packing and crusting
d. Maintain a more uniform distribution of moisture throughout the season

All porous mulches (straw, leaves, partially rotted sawdust, corncobs, or peat moss) and reflective mulches (aluminum foil, newspaper) will give results similar to black plastic except they will lower soil temperatures. For this reason, they should be applied to warm-season crops only late in the growing season. They present no particular problem on cool-season crops after seedling emergence.

Never lay non-permeable mulches such as black plastic, paper, or aluminum over dry soil.

Cropping control methods take advantage of crop rotation to obtain changes in the environment which will keep weeds under control. Often the new crop successfully competes with the weeds that were a problem in the previous crop. Sometimes other methods of weed control are combined with cropping. For example, chemical controls are combined with rotation when atrazine is applied to sweet corn or popcorn following other vegetable crops in which grasses have become a problem.

Biological methods use living organisms to control weeds. One example is allowing geese to feed on certain grasses, especially in strawberry plantings. Future biological control methods may include plant varieties with increased vigor, and insects and disease organisms that selectively attack weeds.

Chemical control of weeds offers the greatest single potential for commercial growers. Many selective commercial herbicides are available.

Weed prevention and eradication coupled with mechanical, cropping, and biological control are all important methods for the commercial vegetable grower and gardener. In addition, the commercial grower needs to make judicious use of herbicides.

HOME GARDEN WEED CONTROL

When consulting with the home gardener, avoid recommending herbicides for weed control in the vegetable garden. This is suggested because:

1. There is no one herbicide available that can be safely used on all kinds of vegetables growing in the garden. Also, no one herbicide will control all weeds.
2. Herbicides are difficult to apply at proper rates in small areas with hand sprayers. Some areas will not receive enough herbicide for effective weed control, and other areas will receive such heavy rates that the crop will be damaged or killed.

Specific weed control suggestions you can safely make for the average home gardener include:

1. Eliminate young weed seedlings with shallow hoeing or cultivation. Most annual weeds can be killed with one or two cultivations. Perennial weeds can be killed by any kind of cultivation which removes all top growth at frequent intervals.
2. Keep weeds and weed seed out of the garden during the idle fall and winter months by sowing a thick cover crop in late summer or fall (use annual ryegrass or spring oats).
3. Use a herbicide registered for homeowner use, provided there is no danger of spray or dust drifting from the target crop to susceptible garden plants. Granular formulation can be applied using a glass jar with a perforated top. A small compressed-air sprayer can be used to apply any liquid or wettable powder.

To calculate how much chemical to use in small sprayers, fill the sprayer with water and mark the level; spray the water as evenly as possible onto an area of 1,000 square feet, and then measure the amount of water used. Follow the manufacturer's recommendation for small-area spraying. One ounce per 1,000 square feet is approximately equal to three pounds per acre. For liquid measure, two level tablespoons is one ounce; 16 ounces (1 pint) per 1,000 square feet is about equal to five gallons per acre.

INTEGRATE MANY CONTROL SYSTEMS

The high cost of labor has caused growers to rely more on chemicals than on cultivation and hoeing or pulling. Unfortunately, chemicals alone cannot do an efficient, satisfactory job. A few weeds always escape, and new, chemically resistant weed species may begin to increase. One early shallow cultivation, or the use of black plastic mulch often solves both of these problems and benefits crop growth and development.

The choice of herbicide for a particular field is dictated by the kind of vegetable being grown and the weed to be controlled. There are many situations in which the target weeds cannot be controlled chemically if a particular vegetable is being grown. However, if a different crop is grown, another herbicide can be used to control the weeds quite readily. For example, ragweed is hard to control in cabbage because most herbicides that are currently registered for use on cabbage do not control ragweed. On the other hand, several herbicides for use in corn and bean

fields are selective for those crops, and control ragweed. This principle applies to many crops and weeds. Thus, crop rotation is a simple, effective method for obtaining good weed control on a long-range basis.

The higher the weed seed population in the soil, the more difficult it is to achieve good weed control. Therefore, weeds should be prevented from seeding in and around fields (fence rows and ditchbanks) whenever possible. Destroy all weeds immediately after a crop is harvested, till, and plant to a cover crop.

HOW HERBICIDES ARE USED

Herbicides are used either on foliage or in the soil.

Foliage Applications

These treatments are made to leaves of growing plants, usually as liquid sprays. They kill plants by either contact or translocation.

By contact: This treatment kills only the plant parts actually contacted by the herbicide. Roots, which receive no herbicide, may die because they are deprived of the essential nutrients from the leaves, which have been treated. Adequate distribution of the herbicide over the foliage is essential. Selectivity may depend on arrangement and angle of leaves, differential wetting, location of growing points, or spray placement. Contact herbicides are most useful to control weed seedlings.

By translocation: This treatment kills the entire plant because the herbicide moves within the plant. For example, when applied to the leaves, the herbicide is translocated to the roots. It may also move from older leaves to young growing points. Therefore, herbicides of this type are used on perennial plants as well as annuals. Selectivity depends primarily on physiological or biochemical differences between plants.

Soil application

These treatments are usually applied to the surface of the soil, but may also be incorporated into the soil by cultivation or may be injected below the soil surface.

Timing the application in relation to the growth stage of the weeds and crop is important. The application may be made preplant, preemergence, or postemergence.

Preplant treatments are applied before the crop area is sown or planted. Some herbicides used in this way act on germinating seedlings; others may kill weed seeds as well. Most preplant herbicides must be thoroughly incorporated into the soil soon after application. Directions for incorporation are given in this year's commercial vegetable pest control guide.

Chemicals used in preemergence treatments are applied after seeding, but before the weed or crop emerges. The chemicals may control weeds by (1) killing weed seedlings, or (2) establishing a toxic layer of chemical on or near the soil surface in which germinating seeds and young seedlings cannot survive. For successful preemergence treatments, the crops either must be tolerant of the chemical at the seedling stage, or the toxicity must have disappeared before the crop emerges. Preemergence treatments generally require a larger volume of water per acre than postemergence treatments. Application can be made at seeding or just before the crop emerges.

A smooth, well-prepared seedbed which is free of clods is necessary for best results. The surface soil should be moist and the temperature favorable for the rapid germination of weed seeds.

Postemergence treatments are applied after the crop and weeds have emerged. A selective chemical is used; the weeds are killed, but the desirable plants are not harmed. The kind of herbicide used depends on (1) the susceptibility of the weed, and (2) the tolerance of the crop to the chemical. Treatment at the correct stage of crop development is important. Since young weeds are most susceptible to chemicals, early treatments will require less herbicide and will result in less damage to crops from weed competition and from spray equipment. Sometimes a herbicide may be applied post-emergence to the crop but preemergence to the weeds. For example, a crop may be cultivated and then a herbicide applied to the clean-cultivated soil to control subsequently germinating weeds.

MOISTURE OR MECHANICAL INCORPORATION

Herbicides (liquid or granular) applied to the soil surface are most effective when either applied to moist soils or followed by rainfall or irrigation. Examples of moisture-incorporated herbicides are Dacthal, Norex, Pyramin RB, Tenoran, and Vegadex.

Other herbicides require mechanical or physical incorporation into the soil. A few of these are Eptam, Prefar, Ro-Neet, Sutan, Tillam, and Treflan. Dymid and Enide benefit from either moisture incorporation or mechanical incorporation. A good, general rule is to incorporate either immediately after application or as soon after application as possible. Treflan is inactivated by sunlight if not incorporated within several hours.

Chemicals to be incorporated should not be applied to rough, cloddy soil because the herbicide will be distributed unevenly as the clods break up. Several tools are used for incorporation, but all are not equally satisfactory.

The double disk, a highly effective tool for soil preparation, is often used for incorporating herbicides. Unfortunately, it can be a poor tool for the latter use unless it is adjusted carefully and used properly. If the disk angle is excessive, much of the treated soil is thrown towards the outer edges of the disked area; however, if the angle is not wide enough, inadequate mixing may result. Thorough mixing can be obtained by properly adjusting disk angle and depth and then cross-disking the field at the proper tractor speed for prevailing soil type and moisture conditions. Less thorough incorporation can result in irregular or streaked patterns of poor weed control and occasional crop injury. The spike-tooth harrow, rotary hoe, and cultimulcher have not usually been satisfactory for incorporating herbicides.

SELECTIVE HERBICIDES

A selective herbicide is one which significantly retards or kills the weed without significantly damaging the crop. Ideally, the weed is killed; sometimes its growth is retarded long enough for the crop to become dominant.

A herbicide is selective to a particular crop only within certain limits; these limits are determined by various factors because in any area there is a complex interaction between plants, their environment, and the herbicide. Because of these variables, and because of varying environmental conditions and methods of herbicide application, selective herbicide control of weeds is relative, not absolute.

HOW TO APPLY SELECTIVE HERBICIDES

If a selective herbicide is not used properly, it is possible to injure the crop or fail to obtain good weed control. The following suggestions will minimize your risk.

(1) Read the label. Herbicide labels are precise, indicating the crops on which the herbicide may safely and legally be used, the weeds it will control, the rates you should use, and any special techniques which may be required. Read the label and follow its directions.

(2) Choose the correct sprayer. Low-volume, low-pressure boom sprayers are recommended for weed control with either broadcast or band application; these sprayers usually apply 20 to 40 gallons per acre at about 30 to 40 pounds per square inch (psi).

SPRAY ADJUVANTS OR ADDITIVES

The word adjuvant is used for any chemical that, when added to a liquid spray, makes it mix, wet, spread, stick, or penetrate better. Spray adjuvants to be used with herbicides often serve a distinctly different function than those to be used with insecticides and fungicides. For example, oil-type adjuvants used with atrazine greatly improve penetration of the chemical into crop and weed leaves, rather than merely giving more uniform coverage. Do not use any adjuvant with herbicides unless there are specific recommendations for its use, either on the label or from county or state Extension personnel. Plant damage or herbicide residues on the crop can result from using an adjuvant that is not recommended.

SPECIFIC WEEDS IN VEGETABLE PLANTINGS

QUACKGRASS: A combination of fall and spring herbicide applications plus tillage offers the most efficient control of this common, perennial, problem grass. Your County Extension Agent can suggest specific chemicals.

NUTSEDGE (NUTGRASS): Nutsedge reproduces primarily by small tubers or nutlets which form in the summer and fall. Complete foliage control is therefore necessary from early July until a hard freeze occurs. Serious infestations result from poor drainage, improper crop and herbicide rotations, and failure to control nutsedge foliage after the vegetable crop is removed in the late summer or early fall.

Chemicals and tillage together help to prevent foliage growth and tuber formation. With warm soils, preplant preemergence incorporated applications are preferred. For early planting when the soil is cold, better results can be obtained by delaying applications until the nutsedge is beginning to emerge. Granulars can be broadcast over emerged crops. The soil and plant surfaces should be dry and the field cultivated immediately after treating.

GALINSOGA: Galinsoga is a serious problem for most vegetable growers even though it is merely a summer annual broadleaf weed. It has become a problem because few chemicals kill control it, especially in the more non-competitive row crops; and because it has a short life cycle and reproduces rapidly by seed.

Galinsoga begins to flower as soon as it has six pairs of leaves. Ripe seed can be produced 12 to 14 days from the time flower bud initials are first seen, and is capable of germinating immediately. In this manner, four to five generations can be produced from a single seed in one season.

RAGWEED: Ragweed is not adequately controlled by any herbicides currently registered for cole crops (cabbage, cauliflower, broccoli, Brussels sprouts), and they must be rotated with other crops on which it can be controlled.

The County Extension Agent can tell you which herbicides are registered to control ragweed.

CONTROLLING ALL OTHER WEEDS: For control suggestions for all other weeds in vegetable crops, contact your County Agricultural Extension Agent.

A FEW FINAL REMINDERS

Know your weeds. This is important because several chemicals are effective on certain weeds only. For instance, at the recommended rates, Prefar kills annual grasses such as crabgrass and foxtails but it fails to kill many broadleaf weeds. If weeds such as ragweed are present, Prefar will appear ineffective.

Use the recommended rate of application. The selectivity of chemicals for crop plants (killing weeds and not the crop) occurs only when the effectiveness range of the chemical and the tolerance range of the crop plant overlap. No crop plant is completely resistant to herbicide injury.

Recommended rates of application should differ with soil type. Lower rates should be used on light or sandy soils and higher rates on silt and clay loams or heavier soils.

Know the herbicide's limitations. These appear on the product label. The following is an example of information given on labels:

"Treflan will not control certain resistant weeds such as cocklebur, velvetleaf, jimsonweed, ragweed, Venice mallow, and nutgrass."

Avoid 2,4-D herbicide injury: Three formulations of 2,4-D are available--amine, sodium salt, and ester. Amine and sodium salt formulations of 2,4-D are recommended when this herbicide is used near susceptible crops. Ester formulations of 2,4-D are volatile and tend to cause more crop injury than either amine or sodium salt formulations; thus, ester formulations should not be used near susceptible crops (grapes, fruit trees, ornamentals, soybeans, snap beans, tobacco, and tomatoes).

Know which herbicides are very toxic. Although most herbicides have moderate to low toxicity, Premerge and Paraquat are highly toxic.

Always leave a "check strip." Small, properly placed check or guard-row strips can be an invaluable tool for the grower when weed control fails or injury results. Often, it supplies the only reliable clues to future corrective action.

Read and follow the label. The single most important step the applicator can take to prevent crop injury and other possible herbicide problems is to read and follow the directions on the label. In fact, the failure to do so is illegal! Misapplication can result in both civil and criminal fines and confiscation of the food crop.

TERMS USED IN SELECTIVE WEED CONTROL

Absorption: The process by which herbicides are taken into plants, by roots or foliage.

Adsorption: The binding of substances on the surfaces of solids.

Annual: A plant that completes its life cycle in one year and then dies. Common sub-classifications are summer annuals and winter annuals.

Aromatics: Compounds derived from the hydrocarbon benzene (C_6H_6).

Band application: An application of spray or dust to a continuous restricted area, such as in or along a crop row, rather than over the entire field area.

Basal treatment: An application of herbicides to the stems of plants at and just above the ground line.

Biennial: A plant that completes its growth in 2 years. In the first year, it produces leaves and stores food; in the second year, it produces fruits and seeds.

Broadcast (blanket) application: An application of spray or dust over an entire area rather than only on rows, beds, or middles.

Carrier: The liquid or solid material added to a chemical compound to facilitate its storage, shipment, or use in the field.

Compatibility: Quality of two compounds that permits them to be mixed without effect on the properties of either.

Concentration: The amount of active material in a given volume of diluent. Recommendations and specifications for concentration of herbicides should be on the basis of pounds-per-unit volume of diluent.

Contact herbicide: A herbicide that kills primarily by contact with plant tissue rather thar as a result of translocation.

Cotyledon leaves: The first leaf or pair of leaves of the embryo of seed plants.

Crown: The point where stem and root join in a seed plant.

Directed spray: An application made to minimize the amount of herbicide applied to the crop. This is usually accomplished by setting nozzles low with spray patterns intersecting at the base of the plants just above the soil line.

Emergence: Appearance of the first part of the crop plant through the ground.

Emulsifying agent: A material which facilitates the suspending of one liquid in another.

Emulsion: A mixture in which one liquid is suspended in minute globules in another liquid; oil in water, for example.

Growth stages:

1. Tillering stage: when a plant produces additional shoots from a single crown, as in corn.
2. Jointing stage: when the internodes of the stem are elongating.
3. Boot stage: when the seed head of a plant begins to emerge from the sheath--usually applied to corn and grain crops.

Herbicide: A chemical used for killing plants.

Perennial: A plant that lives from year to year. In cold climates, the stem dies, but the root persists.

Postemergence treatment: Treatment made after the crop plants emerge.

Preemergence treatment: Treatment made after a crop is planted but before it emerges.

Preplant treatment: Treatment made before the crop is planted.

Rate and dosage: These terms are synonymous, but "rate" is preferred. Usually refers to the amount of active ingredient material (such as 2,4-D acid equivalent) applied to a unit area (such as 1 acre) regardless of percentage of chemical in the carrier.

Rhizome: Underground stem capable of sending out roots and leafy shoots.

Selective Herbicide: A compound more toxic to weeds than to the crop in the field. Helps control weeds without damaging the crop.

Soil sterilant: A material which makes the soil incapable of supporting plant growth. Sterilization may be temporary or practically permanent.

Spray drift: The movement of airborne spray particles from the spray nozzle to beyond the intended contact area.

Stolon: Runners or stems that develop roots and shoots at the tip or nodes, as do strawberry plants.

Stool: To produce crown shoots; to tiller.

Surfactant: A material in pesticide formulation which imparts emulsifiability, spreading, wetting, dispersability, or other surface-modifying properties.

Suspension: A liquid or gas in which minute solid particles are dispersed but not dissolved.

Systemic herbicide: A compound which is translocated within the plant and has an effect throughout the entire plant system.

Translocation: Transfer of food or other materials such as herbicides from one plant part to another.

Volatile: Quality which makes a compound evaporate or vaporize (change from a liquid to a gas) at ordinary temperature when exposed to air.

Wetting agent: A compound which, when added to a spray solution, causes it to spread over wet plant surfaces more thoroughly.

For additional information about weed control for vegetable crops, consult the following publications:

Ashton, F. M., and W. A. Harvey, "Selective Chemical Control," Circular 558, University of California, Berekely.

Lockerman, R. H., A. R. Putnam, R. P. Rice, Jr. and W. F. Meggitt, "Diagnosis and Prevention of Herbicide Injury", Extension Bulletin E-809, Michigan State University.

New York State College of Agriculture, Ithaca, and New York State Agriculture Experiment Station, Geneva, "1975 Vegetable Production Recommendations."

Ontaria Herbicide Committee, "1974 Guide to Chemical Weed Control," Ministry of Agriculture and Food, Ontario, Canada.

The Pennsylvania State University, "1975 Commercial Vegetable Pest Control Guide," Cooperative Extension Service, University Park, Pennsylvania.

Putnam, A. R., and A. P. Love, "1975 Chemical Weed Control for Horticultural Crops," Department of Horticulture, Michigan State University.

University of Illinois Agriculture Experiment Station, "Weeds of the North Central States," North Central Regional Publication Number 35, Circular 718.

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